Space Weather Technical Forecast

Issued on Sunday, 03 September 2023 at 13:09 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Moderate storms expected 03 Sep due to CME arrivals and ongoing fast winds. Decreasing risk of M-flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with a couple of M-class flares from the AR3413 sunspot region, peaking with a M5.9 at 03/0836UTC. This region has now rotated off the visible disc around the northwest limb. While impossible to analyse, magnetic looping is visible above the region in SDO imagery. The other three sunspot regions on the disc remain smaller and simple, and are either stable or showing signs of decay. A new (and as yet unnumbered) sunspot region has emerged in the southeast, forming a beta configuration quite quickly, so may be an area to keep an eye on.

The CME associated with the M3.3 flare of AR3413 is missing Earth. A further filament eruption was observed from the northwest disc in SDO imagery around 02/1754 UTC. A CME was identified coming off from this eruption, but has been analysed to not be Earth-directed. Further CMEs have emerged from the same region (AR3413) but are considered likely to miss Earth, pending analysis.

Solar Wind / Geomagnetic Activity: The CH40/+ high speed stream gave Elevated solar winds at first, with the influence gradually easing as solar winds show a decreasing trend. Solar winds observed by ACE at L1 were at first elevated at around 550-600km/s, but have now dropped to slightly elevated levels at around 480km/s. Density was largely below average initially, then increased to be above average, peaking near 25pppc by 03/0637 UTC. Total Interplanetary Magnetic Field (IMF), Bt, was Weak at first, but increased to Moderate for a time after 02/2133 UTC. Overall this ranged 5-10nT, with the north-south direction, Bz, predominately negative (southward) ranging between +5 nT and -7nT. Phi angle was variable at first, then became positive (away from the Sun), before becoming negative (towards the Sun) from 02/2000 UTC. Geomagnetic activity has been Active to G1 Minor Storm (Kp4-5).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux declined from slightly elevated but below S1 Minor Radiation storm (around 1pfu) to near background, as the effects of the 01 Sep S1 event eased. GOES16 high energy (greater than 2MeV) electron flux was mainly at background, but briefly Moderate peaking 331 pfu at 03/0230 UTC. The associated 24-hour fluence was well below the Active threshold, with 5.76e6 integrated pfu observed at 03/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: A chance of Moderate activity Day 1 (03 Sep), with a further risk of M-flares from AR3413, but then easing to mainly Low activity as this rotates further onto the far-side, with the other spots on the disc currently smaller and simpler.

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Solar Wind / Geomagnetic Activity: A CME was expected to arrive 03/0600 +/- 9hours, and is from the moderately fast CME which occurred alongside the M-flare of AR3413 on 01 Sep. This may still arrive at some point Day 1 (03 Sep). If it does arrive then ongoing CME influence is likely going into Day 2, before easing. However winds are likely to remain elevated due to the fast winds of CH40/+ and then CH42/+.

Overall Active to G1 Minor storm intervals are expected on Day 1 (03 Sep), but with a chance of rising to give a spell of G2 Moderate storms with any CME arrival, and a slight chance of an isolated G3 Strong Storm interval. Conditions easing Day 2 (04 Sep) onward to mainly Quiet to Unsettled with Active intervals, and a decreasing chance of G1 Minor Storm intervals.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to continue at around background levels, but with an increased chance for a Minor proton storm (S1) on Day 1 (03 Sep), in association with the M5.9 flare from the AR3413 region rotating around the northwest limb. As this area rotates further around the far side the risk is much reduced. High energy (greater than 2 MeV) electron flux is expected to be suppressed at first due to the CME arrivals, before potentially rising as solar wind pressure eases later Day 2 (04 Sep) and Day 3 (05 Sep). There is a chance of Moderate to High flux by the end of Day 2, but more likely Day 3-4 (05-06 Sep). The associated 24 hour fluence is expected to remain below the Active level (1e8 integrated pfu) at first, but with an increasing chance of rising above by Day 3.

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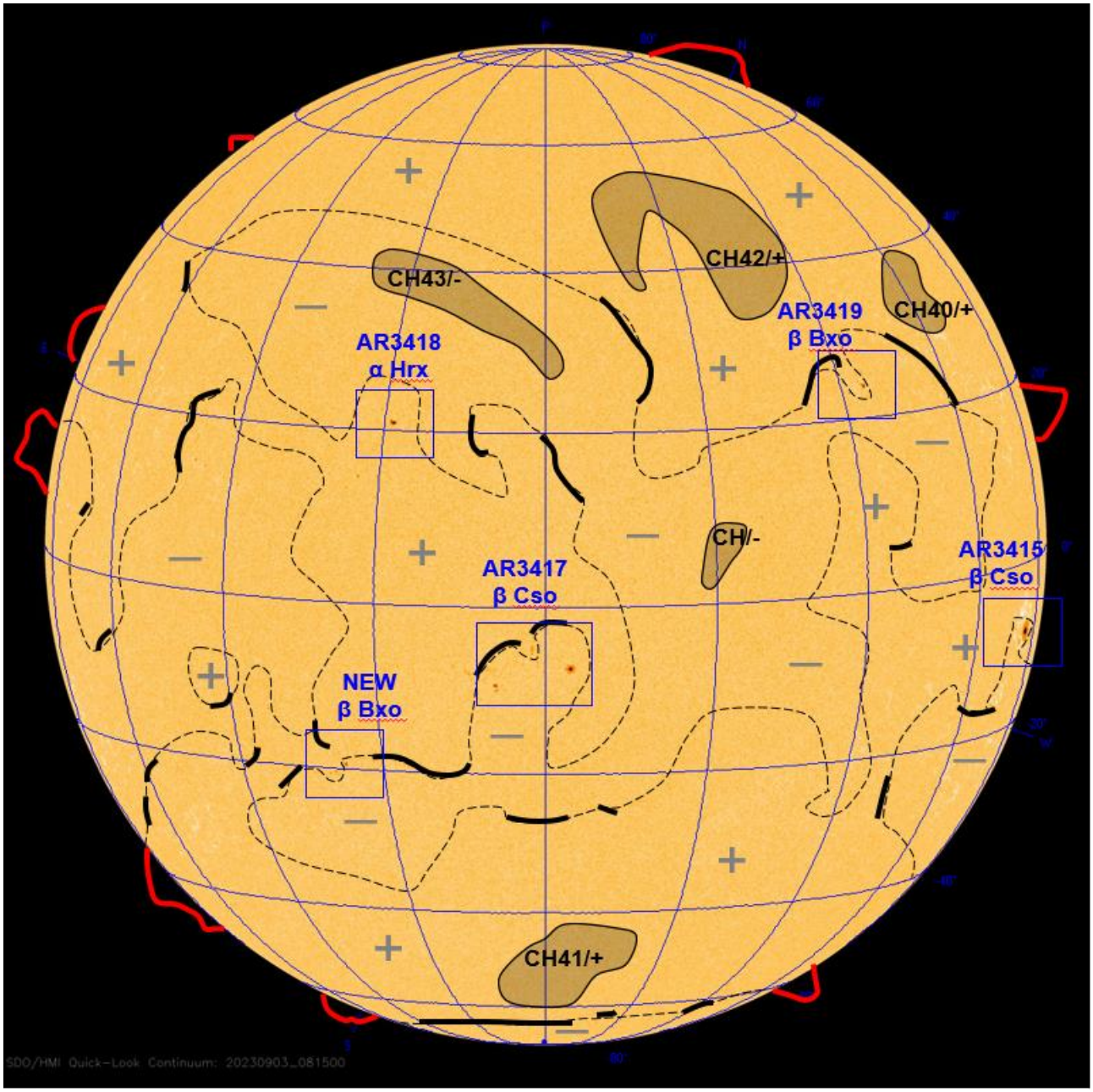
Figure 1. Solar Analysis Valid 03/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth is currently under the influence of a coronal hole high speed stream (CH40/+), as well as a likely glancing blow from the CME associated with a filament eruption on 30/2000 UTC.

A second CME arrival, associated with the M-flare of AR3413 which peaked 01/0352 UTC, was forecast to arrive on Day 1, 03/0600 UTC +/- 9 hours. This may still arrive at some point on Day 1 (03 Sep) as it still falls within the expected arrival timeframe, and combined with previous arrival and coronal hole high speed stream, may give more geomagnetic disturbance. These effects may then linger into Day 2 (04 Sep).
A filament eruption observed in the northwest disc around 02/1750 UTC has been analysed and is not showing any Earth-directed component. Further CMEs from AR3413 have been observed, but are unlikely to be Earth directed, pending further analysis.
Otherwise, background winds are currently slightly elevated, due to the influence of the fast wind from CH40/+. This is expected to be followed by the fast wind from CH42/+ during Day 2 and into Day 3, leading to elevated solar winds remaining likely throughout, perhaps easing Day 4.
Overall Active to G1 Minor storm intervals are expected on Day 1 (03 Sep), but with a chance of rising to give a spell of G2 Moderate storms with any CME arrival, and a slight chance of an isolated G3 Strong Storm interval. Conditions easing Day 2 (04 Sep) onward to mainly Quiet to Unsettled with Active intervals, and a decreasing chance of G1 Minor Storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	30	10	10
Strong	G3	No	10	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
01/0625	Partial	M1.2 AR313	NW	1125	03/0600 +/- 9hrs	Glancing impact

Figure 2a: ENLIL showing expected CME arrival

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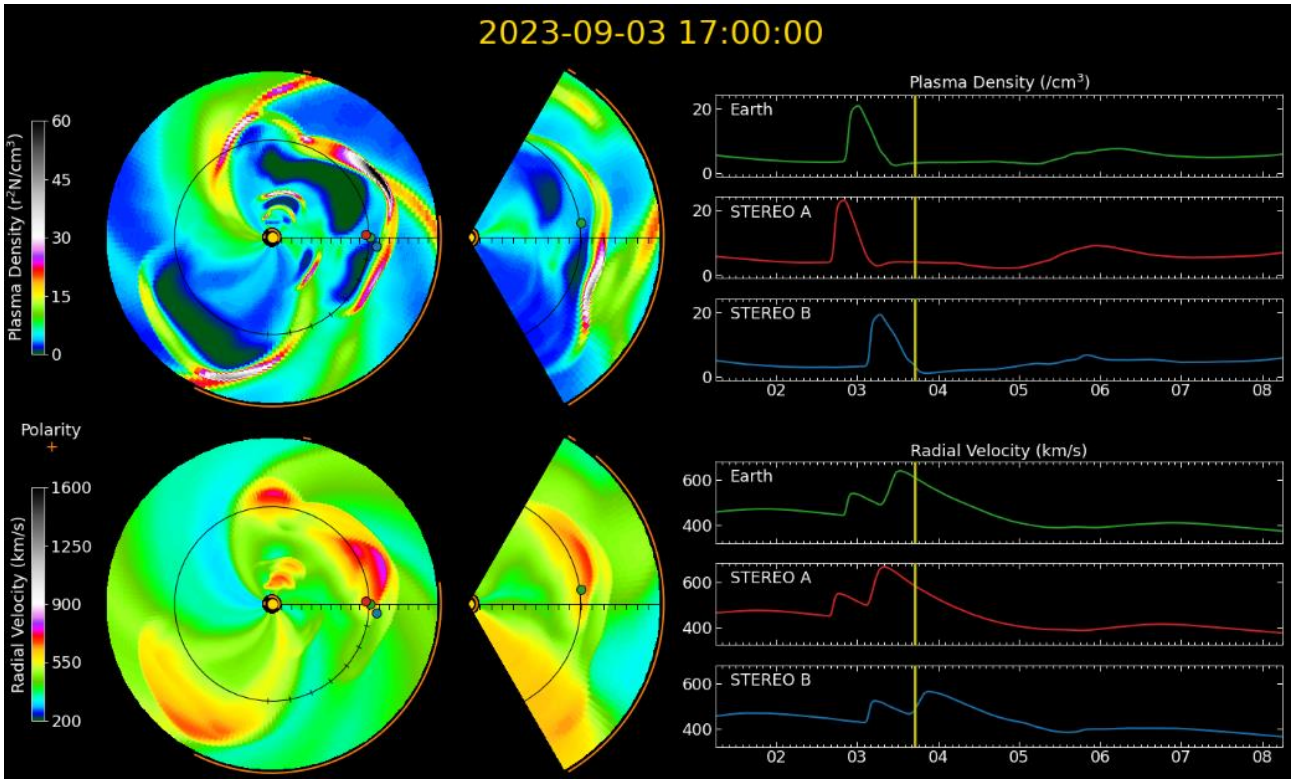
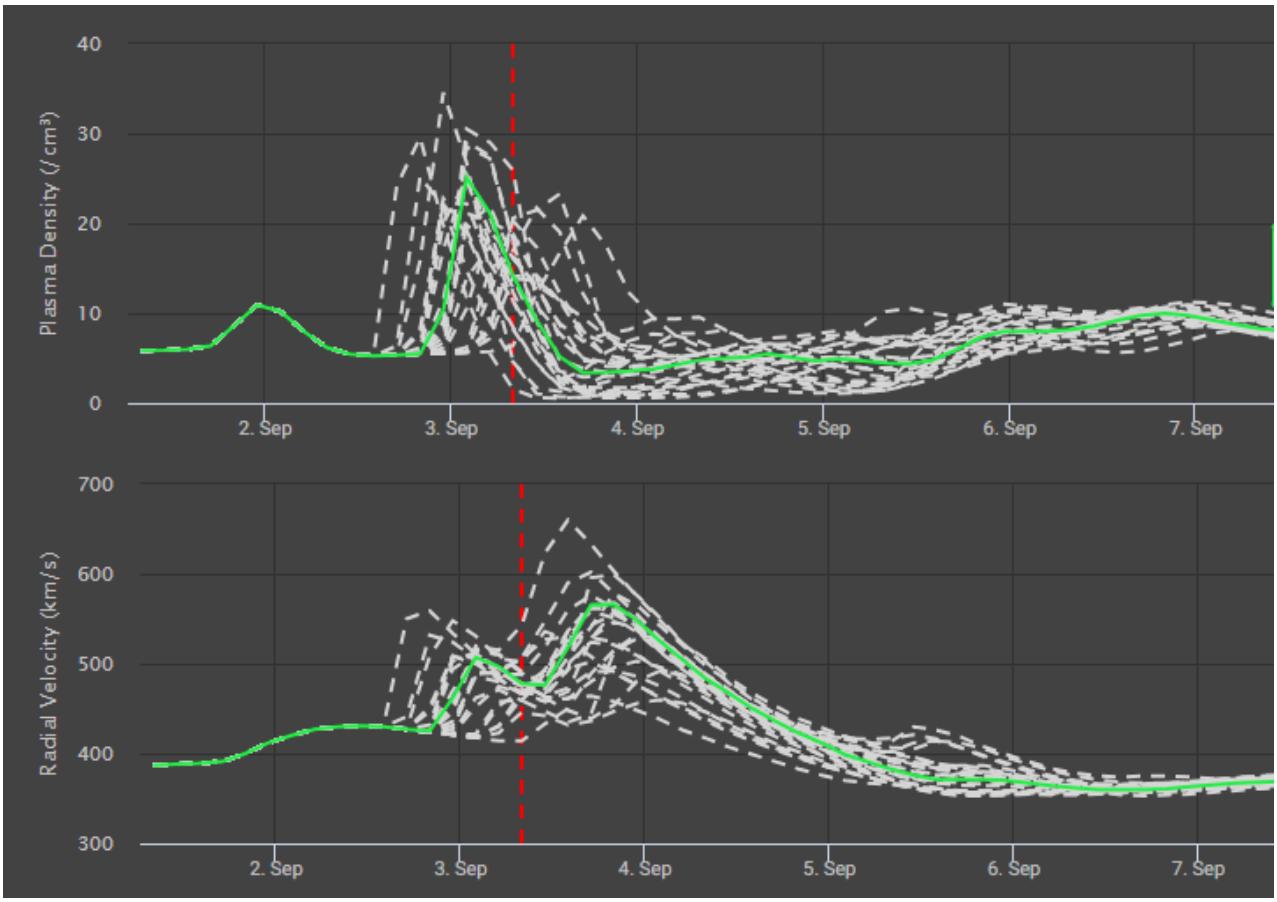


Figure 2b: ENLIL ensemble showing pertubations of CME arrival time.



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Radio Blackouts - X-Ray Flares:
Activity is Moderate, but expected to ease to be mainly Low as AR3413, which is now on the northwest limb, continues to move onto the far-side. This region has been the source of recent significant activity, including a couple of M-flares in the last 24 hours, and with its magnetic canopy remaining visible above the limb will continue to provide a chance of similar activity on day 1 (03 Sep). This risk receding by day 2 (04 Sep).

The other four regions currently on the disc are smaller and simpler, and mostly either stable or showing sign of decay. A new (as yet unnumbered) sunspot region in the southeast has quickly formed into a beta configuration, so may be an area to keep an eye on. Activity is expected to ease to be mainly Low day 2 onward, unless any further development or sunspot emergence occurs.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	35	20	20	30
Very Active	R3 to R5 X Class	No	2	1	1	1

Figure 3: GOES 16/18 X-ray flux.

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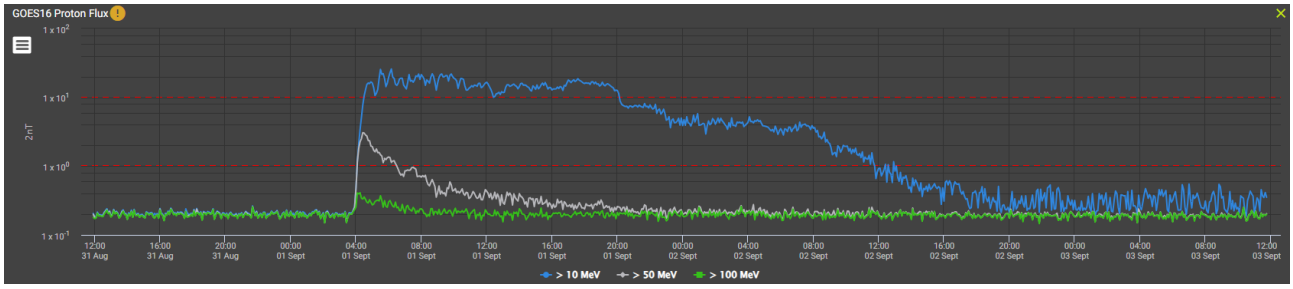
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES-16 has now largely eased to background after the S1 enhancement on 01 Sep. There is a chance for a Minor proton storm (S1) on Day 1 in association with an M-class flare from the AR3413 sunspot region that is rotating off the disc in the northwest. This risk then recedes day 2 onward with this sunspot moving further onto the far-side and the other regions on the disc currently smaller and simpler.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	30	5	2	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: GOES 16 Proton flux.



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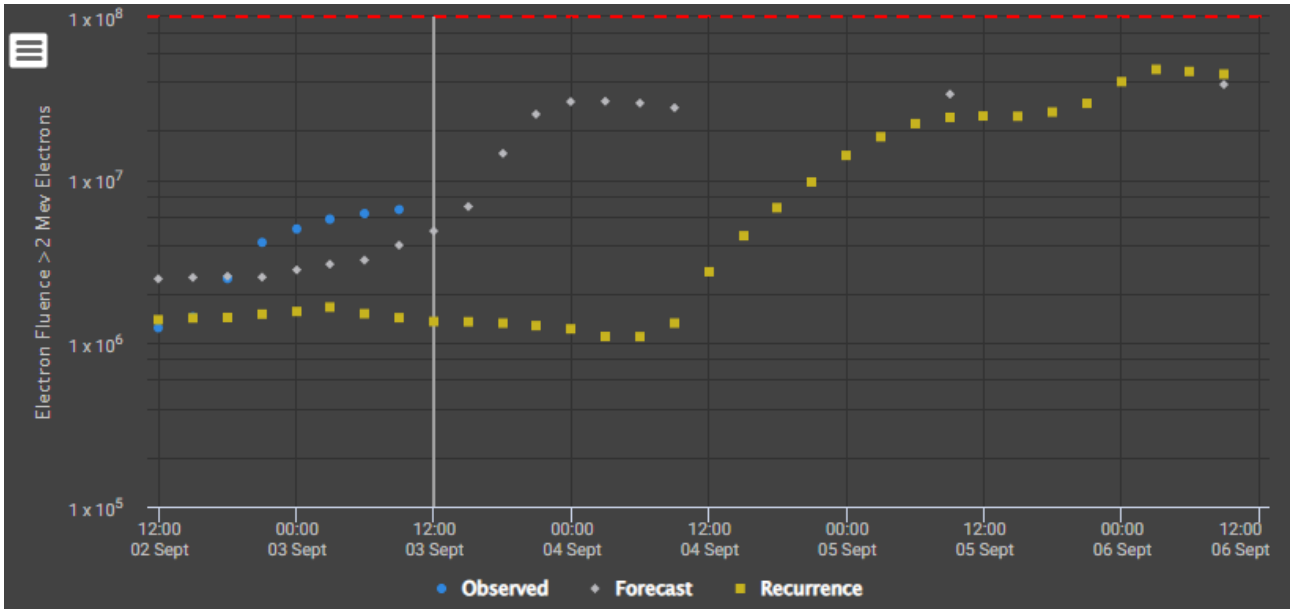
High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at Background to Moderate. Any CME arrival likely to increase electron populations throughout the Van Allen belts, but initially compressing them into lower orbits. As the solar wind pressure eases, mainly day 2 onward (04 Sep), flux will see an increasing chance of becoming Moderate to High.

There is low confidence in this forecast, however as it is very dependent upon the strength of the anticipated CME arrival day 1 (03 Aug). Any further coronal hole fast wind interactions later day 2 (04 Sep) onward could also lead to periods of drop out, along with subsequent enhancements, however this detail currently remains very uncertain.
The associated 24 hour fluence is expected be below the Active (1e8 integrated pfu) threshold day 1 (03 Sep), but with an increasing risk of rising above day 2 (04 Sep). MOSWOC REFM is likely to be poor, increasing fluence too quickly, as this doesn't take account of the forecast CME arrival(s).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	40	60	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: REFM showing observed, forecast and recurrance electron fluence.



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